1° SCIENTIFIC INTERNATIONAL CONFERENCE ON CBRNE

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Standoff detection and classification of chemical and biological hazardous substances combining temporal and spectral laser induced fluorescence techniques

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Scenarios

intended output

infrastructure targets

public / crowded targets

accidental output

industrial accidents

natural events

Fast detection and early identification of hazardous substances with low false alarm rates and low risk for people are essential!

Detection techniques

local information

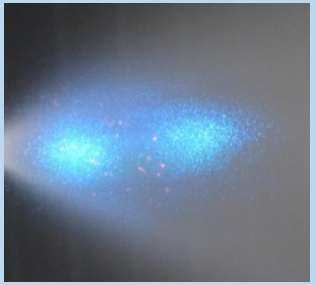
laser based detection

+ fast localization / time-dependent mapping

+ classification

- limited identification

free transmission range, DLR Lampoldshausen



fluorescent aerosol, DLR Lampoldsh.

particle samplers

+ identification ability

- „right“ positioning?

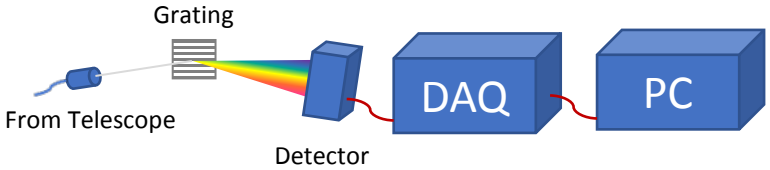
- origin / movement / distribution of cloud?

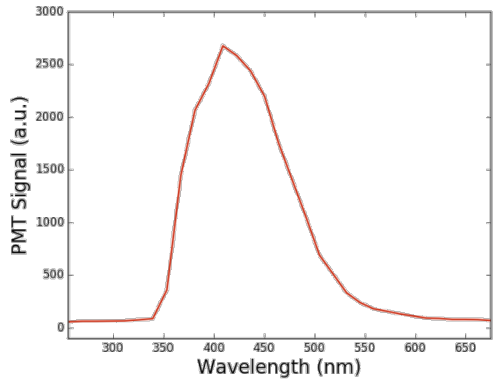
gas chromatograph/ mass spectrometer*

UAV*

LIF detection setup

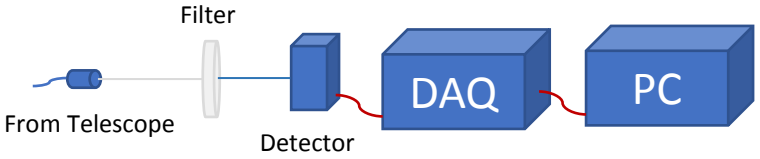
Spectrally resolved LIF

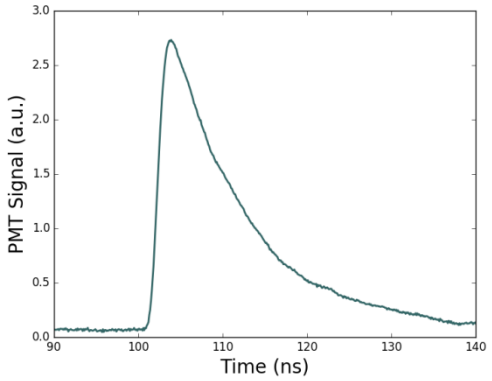




+

Temporally resolved LIF

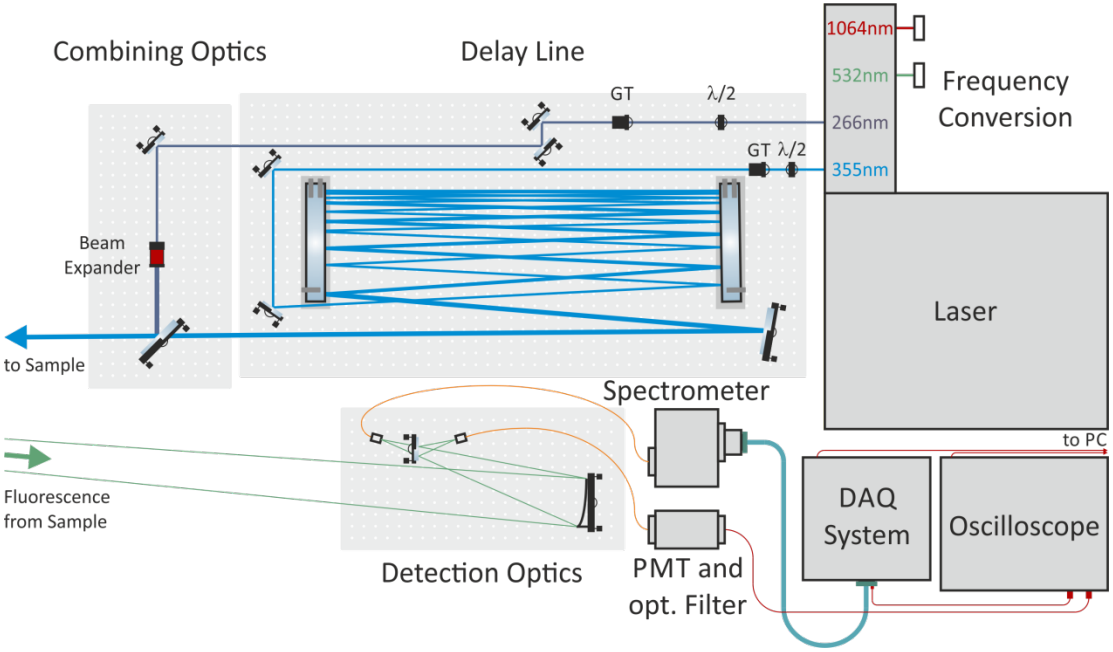


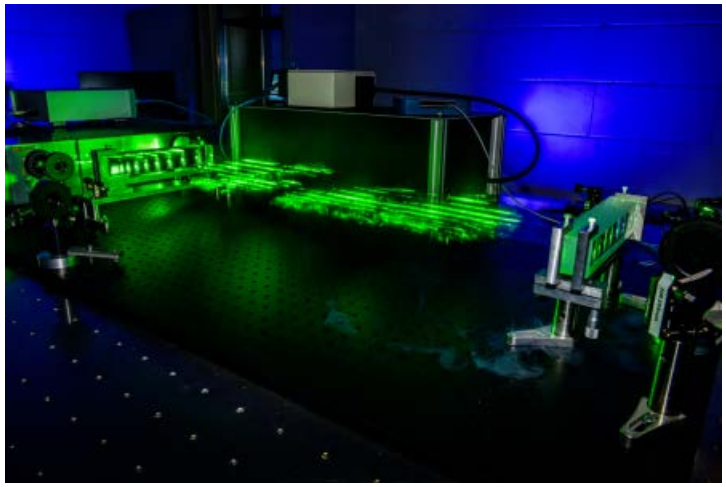


Desired setup features:

- Combination of LIF techniques to obtain non-redundant information for the classification process
- Fast data acquisition to enable online detection
- Compact system to be able to transport setup to external laboratory

Experimental setup

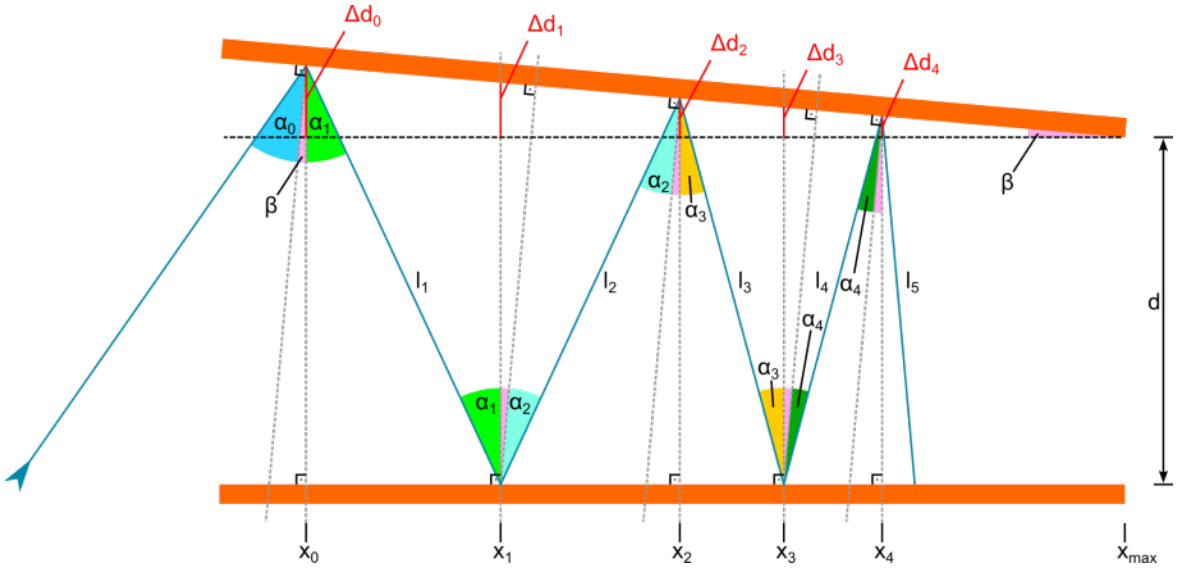


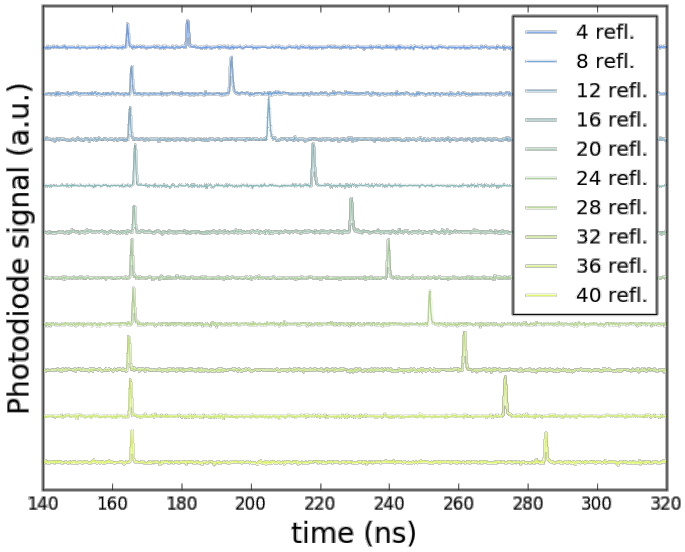


Setup features:

- 32 spectral channels + up to 4 temporal channels
- 100 Hz data acquisition rate (complete spectral and temporal dataset excited by laser pulses with two different excitation wavelengths)
- Modular and transportable system

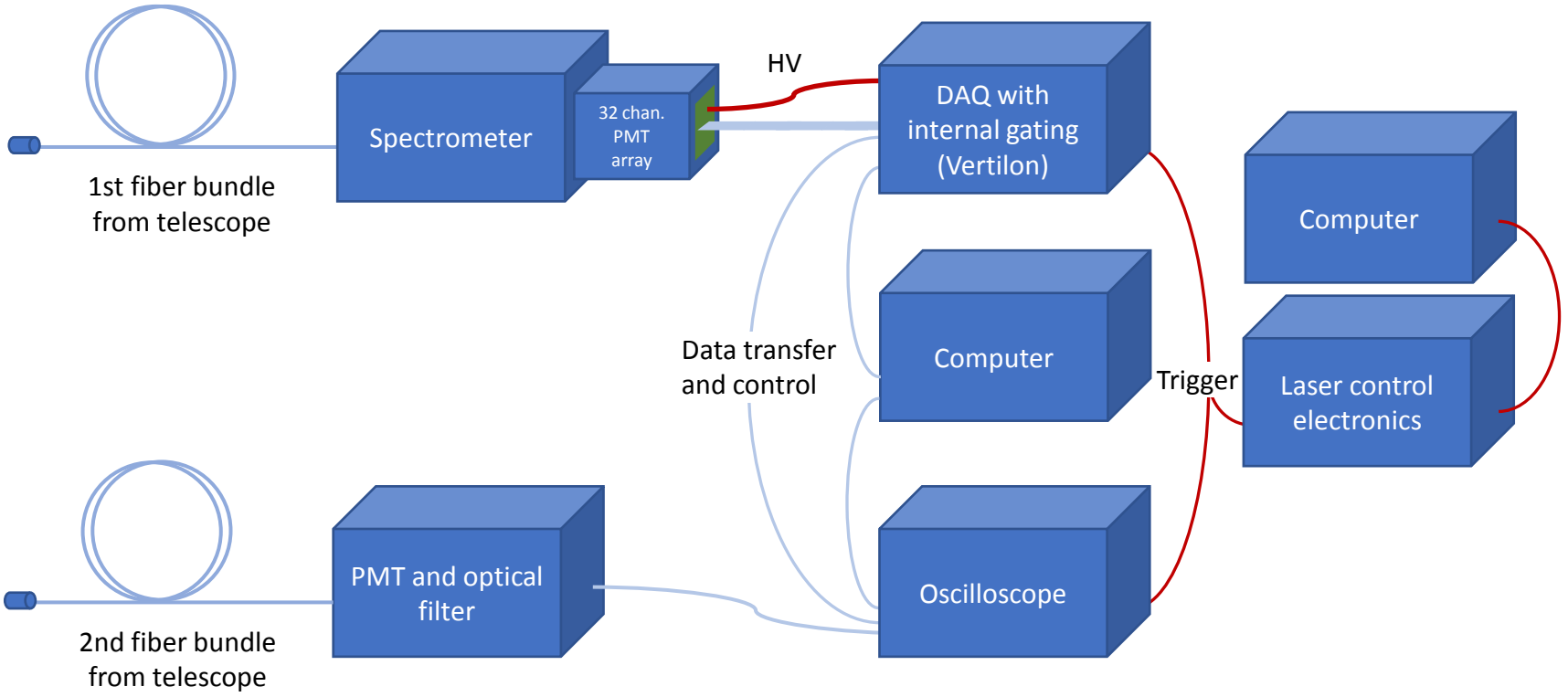
Optical delay line



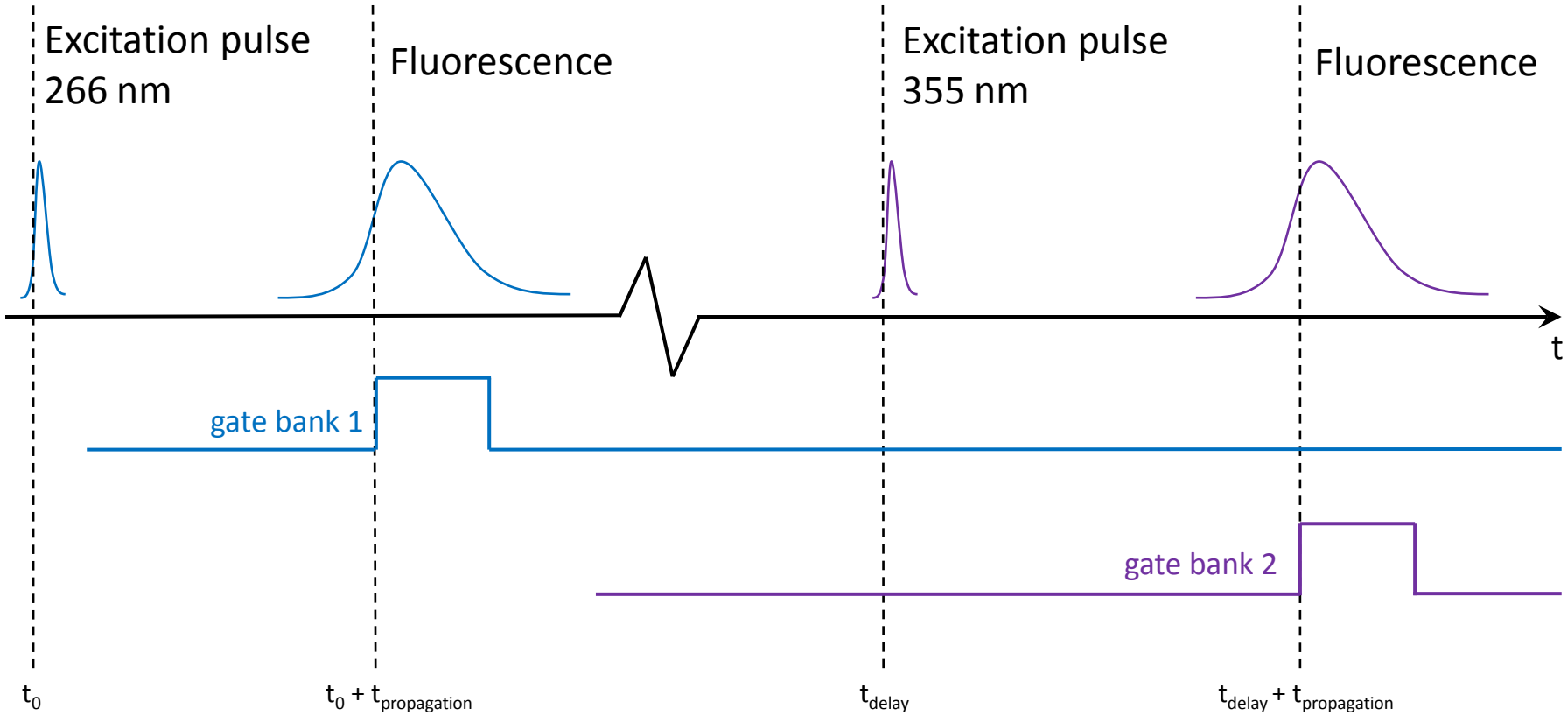


Multiple reflections between plane-parallel mirrors are for temporal separation of laser pulses of different wavelengths.
Up to 40 reflections possible → Delay up to 120 ns

Detection system

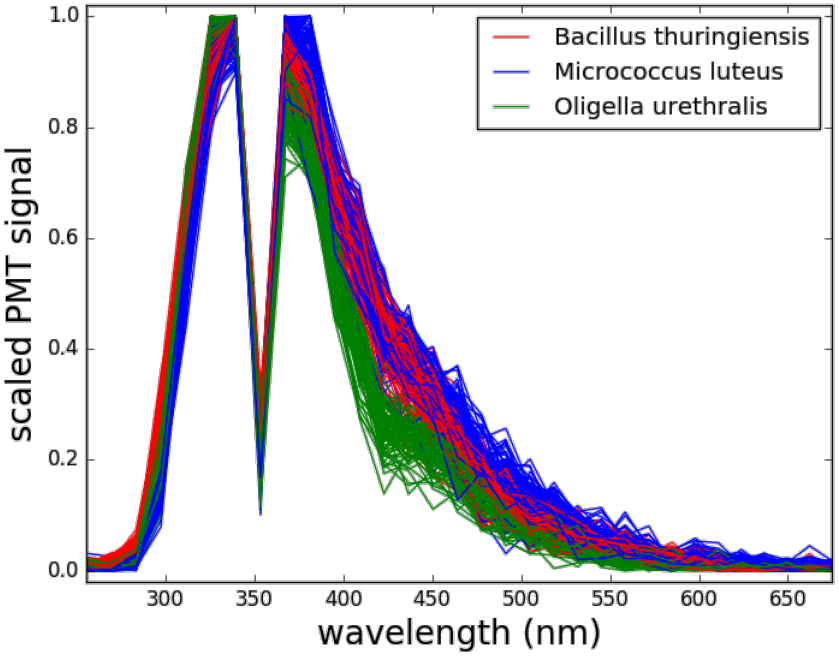


Internal gating of DAQ system

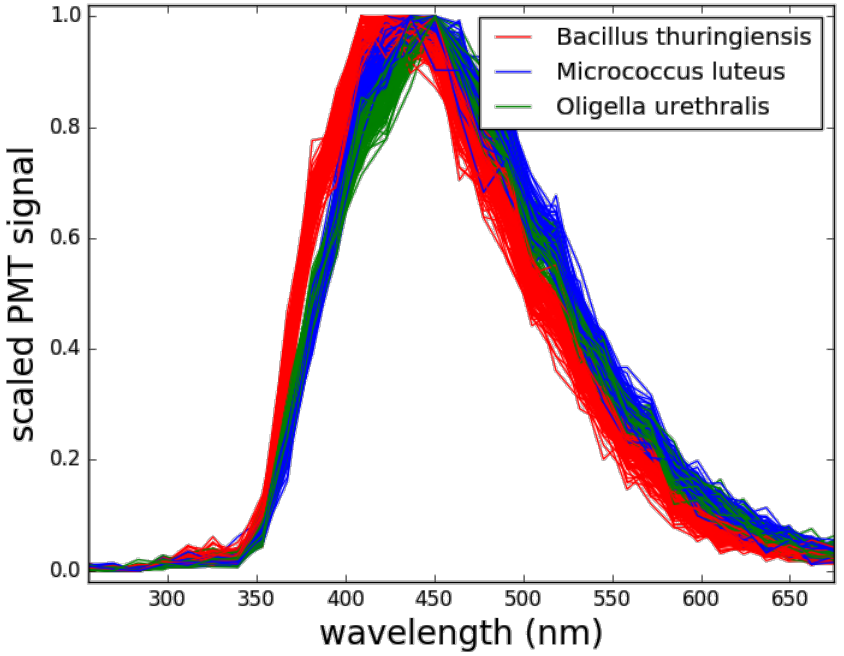


Spectra of three bacteria

Excitation: 266 nm



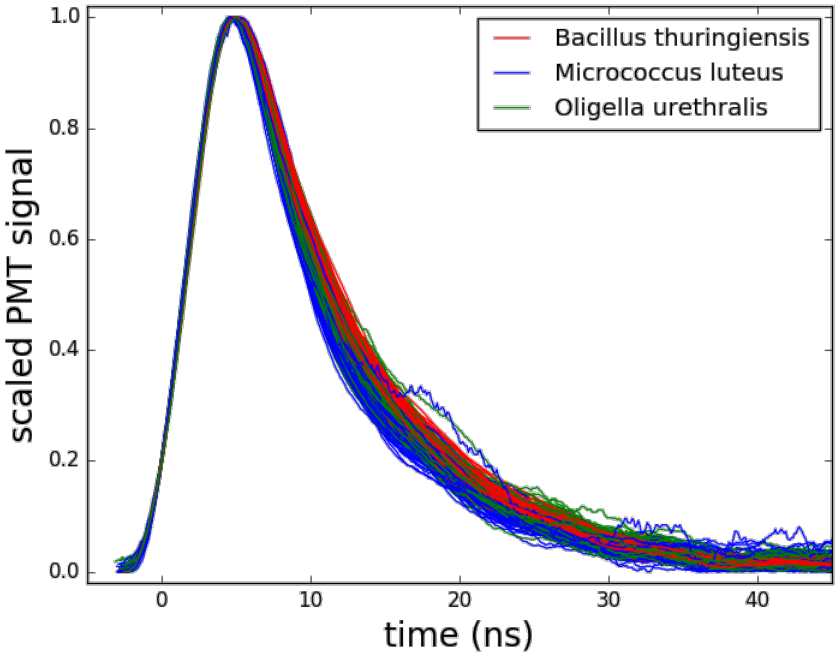
Excitation: 355 nm



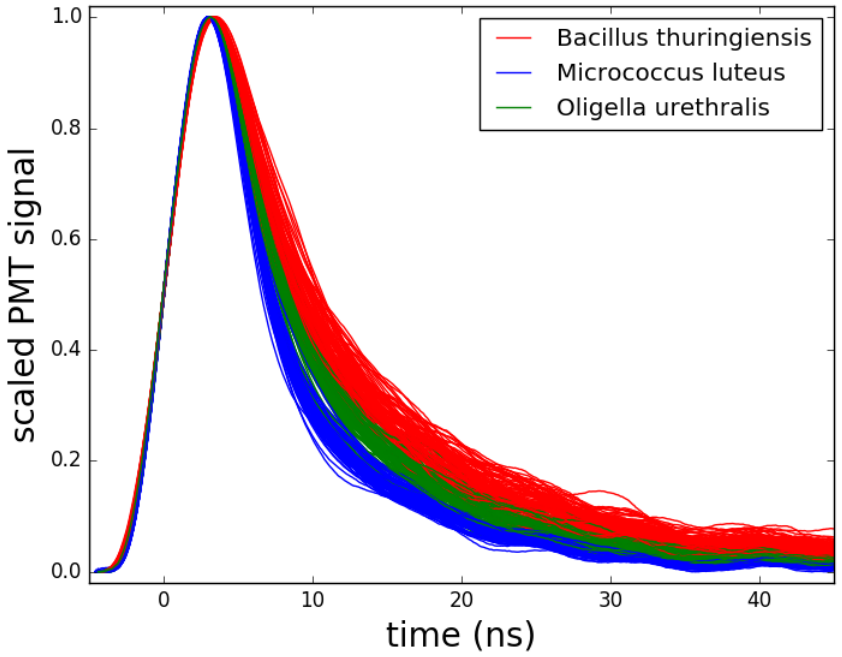
For 266 nm excitation partly overlap of spectral data for *B. thuringiensis* and *M. luteus*.
For 355 nm excitation regions of distinct signals exist for all three bacteria.

Fluorescence decay of three bacteria

Excitation: 266 nm; detection: 310 nm



Excitation: 355 nm; detection: 460 nm



For 266 nm excitation time signal overlaps for all three bacteria.
For 355 nm excitation regions of distinct signals exist.

Classification using C5.0 decision tree

- 500 spectral and fluorescence decay signals for each bacterial sample and excitation wavelength
- Randomized samples for training and testing
- 75% used for training, 25% used for testing the algorithm
- Not optimized parameters used for classification

Spectral data

	B. thur.	*M. luteus*	*O. ureth.*
B. thur.	124	0	4
M. luteus	0	120	0
O. ureth.	1	5	121

Accuracy : > 97%

Flourescence decay dataset

	B. thur.	*M. luteus*	*O. ureth.*
B. thur.	122	0	2
M. luteus	0	125	1
O. ureth.	3	0	122

Accuracy : > 98%

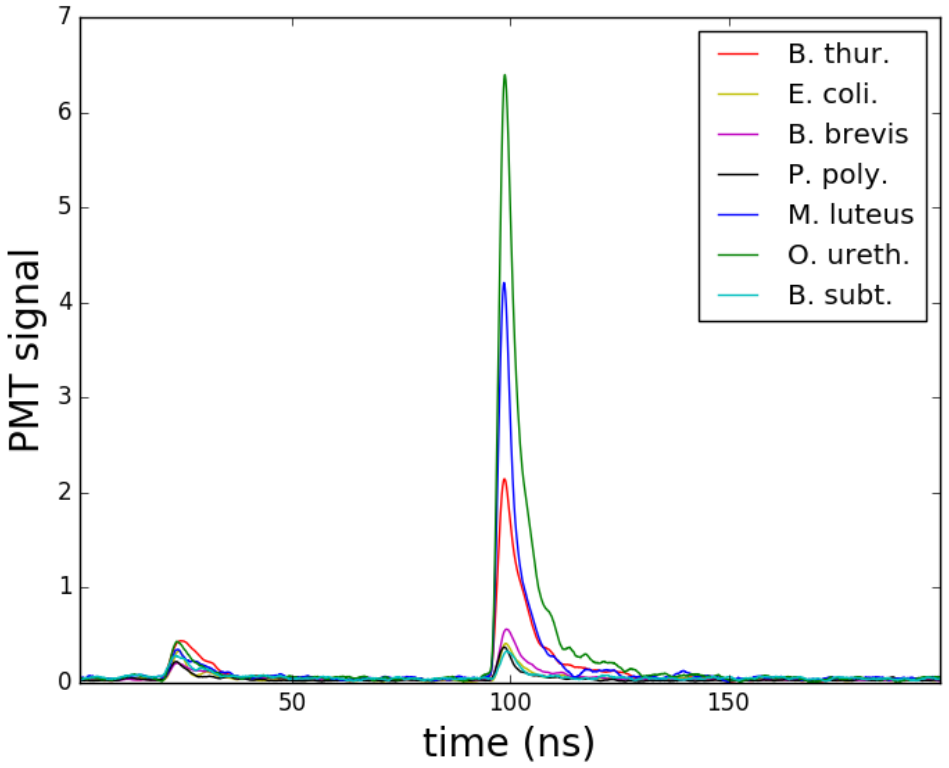
Combined dataset

	B. thur.	*M. luteus*	*O. ureth.*
B. thur.	122	0	2
M. luteus	0	125	1
O. ureth.	3	0	122

Accuracy : > 98%

Fluorescence decay of seven bacteria

- Fluorescence intensities for excitation wavelength of 355 nm vary strongly for different bacteria
- For low intensities signal out of dynamic range of detection, making data incomparable
- Advanced classification algorithms, that neglect low intensity data, may be applied



Summary and outlook

Summary:

- Compact detection system that combines temporal and spectral LIF data
- Fast data acquisition with 100 Hz
- Identification of three bacterial samples within spectral and temporal LIF dataset possible
- Strongly varying fluorescence intensity limits use of decay signal for classification

Additional work and next Steps:

- Investigate more elaborate classification algorithms [1]
- Investigate influence of growth conditions of bacteria [2]
- Extend system and classification procedure to incorporate time signal of more bacterial chemical and background samples
- Investigate third excitation wavelength

[1] M. Kraus, SICC 2017, Poster P1.12; [2] L. Fellner, SICC 2017, Poster P1.11